Release of *Galerucella calmariensis* and *Galerucella pusilla* (Coleoptera: Chrysomelidae) To Control Purple Loosestrife, *Lythrum salicaria*

2002 Report

Prepared by:

Thomas Scudder
Mark Mayer
Daniel Palmer
Robert Huffman
John Lukaszewski

NEW JERSEY
DEPARTMENT OF AGRICULTURE

Phillip Alampi Beneficial Insect Laboratory
New Jersey Department of Agriculture
Division of Plant Industry

INTRODUCTION

Purple loosestrife (*Lythrum salicaria* L.) is an erect, herbaceous, wetland perennial that is native to Eurasia. Since its accidental introduction to North America in the early 1800s, *L. salicaria* can now be found in all contiguous states of the United States (except Florida) and all Canadian provinces (Internet 2000.1). In the United States, it covers approximately 400,000 acres and costs about $45 million a year in control costs and lost forage (Internet 1999). The wetland areas of New Jersey have proven to be very suitable for the establishment of this invasive plant. It can be found throughout most of the state, but it is primarily a problem in the northern and central counties. The damage it inflicts to the state's wetlands is in its displacement of native flora, which is essential for food and cover to native wildlife. It can also decrease the water storage capacity of a wetland, reduce the ability of the wetland to attenuate floods, clog drainage channels and irrigation ponds and reduce the capacity of a wetland to hold and absorb excess water (Mayer et. al. 1996). Control by chemical or mechanical methods is difficult and usually impractical for large, well-established stands (Stuckey 1980). In 1996, the Phillip Alampi Beneficial Insect Laboratory (PABIL) of the New Jersey Department of Agriculture began to investigate the potential of initiating a classical biological control program for purple loosestrife in the state. Two species of Chrysomelid beetles, *Galerucella calmariensis* and *Galerucella pusilla*, native to Europe and introduced to North America in 1992, were obtained by the PABIL from Dr. Bernd Blossey of Cornell University for the purpose of rearing these beetles for release in loosestrife infested wetlands. In 1997, the New Jersey Department of Agriculture (NJDA) and the New Jersey Department of Environmental Protection (NJDEP), Division of Fish and Wildlife entered into a cooperative agreement to conduct a pilot project to release the beetles on five Wildlife Management Areas (WMA) lands to attempt to control purple loosestrife. The release program was extended to include three known bog turtle sites on state owned properties in 1998. The bog turtle, *Clemmys muhlenbergii*, is an endangered native animal species that is adversely affected by purple loosestrife. The turtle is unable to navigate through the stems of the plant and the plant eliminates its food supply. Beginning in 1999 and continuing into 2002 the release of *Galerucella* spp. beetles at known wetland habitats of the bog turtle expanded to include privately owned lands. The NJDEP, Division of Fish and Wildlife, Endangered and Nongame Species Program, working with private cooperators under the United States Department of Agriculture's (USDA) Environmental Quality Incentives Program (EQIP), obtained grants for the purchase of beetles from the PABIL. NJDA personnel from the PABIL carried out all the releases in the expanded program, which resulted in the addition of 31 new sites over the four-year period. In addition to supplying the needed numbers of beetles for both the PABIL's release program and the expanded bog turtle release program in 2002, the PABIL was also able to supply beetles for commercial sale. A total of 75,180 beetles was purchased by other agencies and private landowners in NJ striving to control purple loosestrife on wetlands under their management. This amount was a 62% increase over the 28,450 beetles sold commercially in 2001.

Purple Loosestrife

Visually, purple loosestrife is a beautiful plant. Its showy blue/purple flowers growing in long spikes can be seen from July through September in wetland areas throughout the state. However, a variety of characteristics exhibited by purple loosestrife have enabled this invasive weed to become a major threat to NJ's wetlands. A single, mature plant can bear as many as 3000 flowers capable of producing more than 2.5 million seeds annually. The seeds can remain viable for 10-15 years and are easily dispersed by water and in mud adhering to aquatic wildlife, livestock, and people. It can grow in a variety of substrates and soil types with a pH of 4.0 and above. Established plants can exceed six feet in height, four feet in width and have 30-50 stems. A strong rootstock serves as storage, providing resources for new growth in the spring and regrowth if the above ground shoots are cut, burned, or killed by the application of a foliar herbicide (Malecki et. al. 1993). These characteristics allow purple loosestrife to form large monotypic stands which can out compete or even eliminate native wetland plants which provide both food and shelter for wetland wildlife. Reductions in native plant biomass commonly exceed 50% in affected wetland communities (Internet 1999).

Control Measures

No single chemical or cultural control method for purple loosestrife is available, except where it occurs in small-localized stands and can be intensively managed. In such isolated areas, uprooting the plant by hand and ensuring the removal of all vegetative parts can eliminate purple loosestrife (Malecki et. al. 1993). Limited success has been achieved on agricultural lands with various cultural methods such as water-level manipulation, mowing, cultivation, burning, and herbicide application. However, control attempts utilizing these methods in natural and/or wetland areas are impractical and could possibly result in even more damage to the environment than the purple loosestrife itself. For example, chemical control with glyphosate (Roundup or Rodeo) can be very effective in small infestations. This broad-spectrum, post emergence herbicide has as its chief attribute the ability to translocate to a plant's root system where it hinders the growing ability of a plant. This is particularly significant in controlling perennial weeds whose ability to regenerate growth from below ground plant structures can be prevented. However, since glyphosate is a broad-spectrum herbicide, it can work on the desirable native vegetation as well, which would be detrimental. Therefore, the use of glyphosate would only be practical on small, localized infestations where hand sprayers could be used to specifically direct the herbicide onto the purple loosestrife plants.

The problems associated with chemical and cultural control methods have led scientists to look for other methods that could be used to control purple loosestrife. One such method is biological control. Various weeds such as St. Johnswort or Klamath weed (Huffaker et. al. 1959), alligatorweed (Coulson 1977), and musk thistle (Kok et. al. 1975) have been successfully controlled through classical biological control programs which involves the use of an exotic pest's introduced natural enemies to effect control of that pest. A classical biological control program would be needed for the purple loosestrife since there are no native enemies of this plant in North America capable of maintaining

an acceptable level of control of this exotic plant. In June 1992, following years of extensive studies and testing of both the plant *L. salicaria* and its various natural enemies in Europe, Dr. Bernd Blossey was given approval by USDA-APHIS to introduce a root-mining weevil, *Hylobius transversovittatus* and two leaf-eating beetles, *G. calmariensis* and *G. pusilla,* into the United States. The Phillip Alampi Beneficial Insect Laboratory selected the two *Galerucella* spp. beetles for the control program in New Jersey because they were easier to rear than the root-mining weevil, *H. transversovittatus* and they had the highest biotic potential. The rearing of the insects began in 1996 with the first releases occurring in 1997.

Galerucella spp. Beetles

Galerucella calmariensis and *G. pusilla* are nearly identical both in their life cycles and their morphology. In the field it is extremely difficult to differentiate between the two species, so for expediency they are grouped together as *Galerucella* spp. The adult beetle (Figure 1) is light brown, sometimes with a dark stripe on the elytron. Adults overwinter in the duff or soil beneath old loosestrife plants and emerge in the spring shortly after new loosestrife foliage has emerged. Feeding begins immediately and continues for several days before reproduction starts. Adult feeding is easily recognized by the "shot-hole" appearance in the leaf. The females lay eggs in masses (Figure 1), usually consisting of 2-10 eggs. These masses can be found along the stems, at leaf axils, or under the leaves. They are cream colored and have a noticeable dark stripe (frass left by the female) across the top. Each female is capable of producing 500 eggs during a 45-day oviposition period. Egg laying peaks in May and June, but will continue into mid-July (Internet 2000.2).

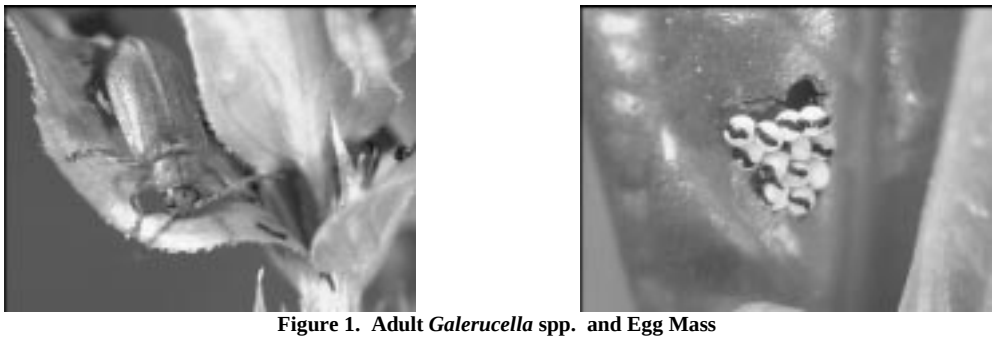

Figure 1. Adult *Galerucella* spp. and Egg Mass
Photos by J. Zhang and J. Lashomb, Rutgers University

Larvae (Figure 2) begin to emerge 7-10 days after oviposition and migrate to the shoot tips. Larvae are yellow to orange, with a black head and only about 6 mm in length when fully grown. First instar larvae feed primarily upon the apical meristem while later instars are less discriminating and feed more heavily upon the leaves. Larvae cause characteristic feeding damage, "window-paning", where they eat the upper layer of the leaf while leaving the lower layer. The larval stage lasts about three weeks, after which they drop to the ground to pupate in the soil or duff beneath the loosestrife plant. The pupation period lasts for about two weeks (Internet 2000.2).

In mid-summer, the insects begin to emerge as adults. After feeding for 7-10 days, the adults move back into the soil or duff to overwinter. Adult emergence typically lasts from July through September. The total maturation time from egg to adult is about 30-45 days (Internet 2000.2).

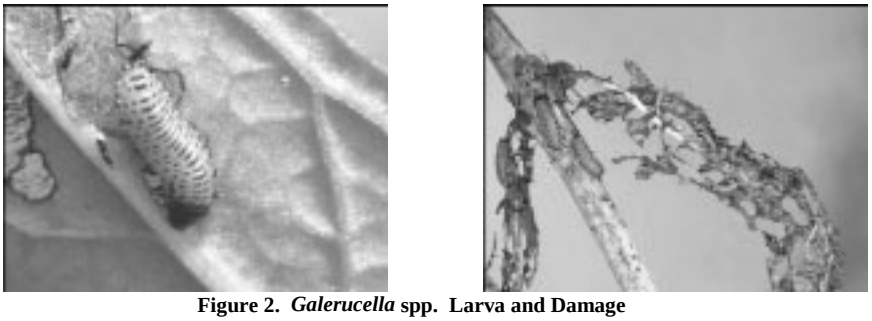

Figure 2. *Galerucella* spp. Larva and Damage
Photos by J. Zhang and J. Lashomb, Rutgers University

MATERIALS AND METHODS

Study Sites

Monitoring and data collection from the five study sites established in 1997 at Amwell Lake WMA, Columbia Lake WMA, Hainesville WMA, Paulinskill WMA and Whittingham WMA continued in 2002. The evaluation and survey methods used were from the Purple Loosestrife Monitoring Protocol, Second Draft developed by Dr. Bernd Blossey of Cornell University in 1997. Five randomly placed one square meter quadrats were set up throughout the purple loosestrife infestation at each of the five study sites. Data was collected twice, once in the spring and once in the fall. Only the quadrats were surveyed at each site and data was recorded for each quadrat. Annual photographs of fixed points at each of the sites are taken to document any changes in the density of the loosestrife infestations. The photographs are taken in early to mid-August when flowering of the loosestrife is still at its peak.

1. Spring. The number of eggs, larvae and adults of overwintering *Galerucella* spp. beetles were counted using a fixed three-minute interval. The life stages present were offspring of established generations of beetles originally released in 1997 and 1998. The data also included the percent leaf area removed by *Galerucella* spp. feeding, the percent plant cover of both purple loosestrife and cattails (*Typha latifolia),* the number of stems of both the purple loosestrife and cattail plants, and the height of the five tallest stems of the purple loosestrife plants and the five tallest cattail stems in each of the quadrats. The spring surveys were performed in mid-May, which appears to be the peak time in New Jersey for the presence of all three-life stages of the *Galerucella* spp. beetles.

2. Fall. The percent cover and the number of stems for both purple loosestrife and cattail and the height for the five tallest stems of both purple loosestrife and cattail were recorded for each quadrat. Using the same stems that were used to measure the height, the number of inflorescences on the loosestrife stems was recorded as well as the length

of the terminal inflorescence on each of the selected stems. The five terminal inflorescences from each quadrat were collected and taken to the laboratory where a 5-cm. section was taken out and the number of flower buds in that 5-cm. section was counted. The procedure was replicated for each quadrat in a site. The total number of inflorescences within each quadrat was also recorded. Monitoring the reproductive parts of the plants can provide evidence of the impact of *Galerucella* spp. First instar larval feeding by *Galerucella* spp. beetles occurs on the apical meristem, which results in reduced plant growth and can prevent flowering (Internet 2000.3). Reduced flowering ultimately results in fewer flower buds capable of producing seed. The percent cover of the five most abundant plant species other than loosestrife and cattail was also recorded for each quadrat. The fall surveys were performed in mid-August, which is within the peak flowering time in our state for the purple loosestrife plant.

Data collection from surveys conducted at the five bog turtle study sites continued in 2002. The evaluation and survey methods at these sites differ from those used at the original five release sites previously discussed. The survey methods used at the bog turtle study sites were employed to reduce data compilation in the field as well as to make it less intensive. These study sites were set up using USDA-APHIS guidelines adapted from the Purple Loosestrife Monitoring Guide, May 1996 of Dr. Bernd Blossey, Cornell University. Each site was configured by establishing a permanent linear transect throughout the purple loosestrife infestation. A five foot PVC pipe was driven into the ground and established as the center post for the transect. From this center post, moving in a straight line, five 30" PVC pipes were placed in the ground at seven meter intervals for 35 meters in two directions from the center post for a total transect of 70 meters. These permanent stakes serve as a reference point for placing a one square meter PVC frame which establishes the 11 data collection quadrats along the transect. When the frame was placed at each quadrat, a note was made of which side of the transect the frame was placed so that it can be positioned in the same place each year. Data collection is accomplished one time per year during the period of near-maximum growth and flowering of the loosestrife. This annual survey should be performed within a few days of the same date each year. Our surveys were performed around the third week of July. The data included the percent cover and the number of stems of purple loosestrife, the number of stems flowering, the percent leaf area removed by *Galerucella* spp. feeding and the number of beetles observed, the height of the five tallest stems of the loosestrife plants, and the percent cover of other plant species in each of the 11 quadrats along the transect. Annual photographs are also taken at each of the sites in order to make loosestrife density comparisons from year to year. This is also accomplished in early to mid-August when loosestrife flowering is still within its peak.

RESULTS AND DISCUSSION

Galerucella spp. Establishment and Dispersal

Establishment of *Galerucella* spp. beetles was documented in 1998 when recoveries were made at four of our five initial release sites (Scudder et. al. 1998). Since that time, the

program has recovered beetles at 92% of the sites, which conclusively shows that the beetles have successfully adapted to NJ's environment. That success is demonstrated by the successful recoveries of overwintering beetles from the 1997-2001 release sites (Table 1).

Table 1. Establishment and Recovery of *Galerucella* spp. Beetles

Site/Release Year	Recovery 2002	Site/Release Year	Recovery 2002
Amwell Lake '97	Y	BT 2 '99	Y
Columbia Lake '97	Y	BT 3 '99	Y
Hainesville '97	Y	BT 4 '99	Y
Paulinskill '97	Y	BT 5 '99	Y
Whittingham '97	Y	BT 6 '99	Y
Allendale '99	Y	BT 7 '99	Y
Waterloo Village '99	Y	BT 8 '00	Y
Kittatinny Valley #1 '99	Y	BT 9 '99	Y
Kittatinny Valley #2 '99	Y	BT 10 '99	Y
Wawayanda SP '99	Y	BT 11 '99	Y
D & R Canal SP '99	N[1]	BT 12 '99	Y
Makepeace Lake '99	Y	BT 13 '99	Y
DOD Ponds WMA '00	Y	BT 14 '99	Y
Black River WMA '00	Y	BT 15 '01	Y
Logan Pond WMA '00	N[3]	BT 16 '01	Y
Flood Gate Rd '00	Y	BT 17 '01	Y
Mercer Co. Park '00	Y	BT 18 '01	Y
TNC Preserve '00	Y	BT 19 '01	Y
Dismal Swamp '01	Y	BT 20 '01	Y
Green Pond Rd '01	Y	BT I '00	Y
Harrier Meadows '01	Y	BT III '00	Y
NJMC – Landfill 1A '01	N[2]	BT IV '98	Y
Skeetkill Marsh '01	Y	BT V '98	Y
2 Wagon Bridge Rd '01	Y	BT VI '00	Y
Columbia Lake #2 '01	Y	BT VII '00	Y
		BT IX '00	N[3]
Totals			**47/51**

[1]the area was treated with an herbicide after release

[2]the area was destroyed by fire the winter after release; loosestrife returned in spring, but no signs of beetles

[3]very little loosestrife remains to sustain the beetles; beetles have probably dispersed to other areas

The continued recovery of beetles in 2002 at each of the original 1997 release sites demonstrates that the beetles will remain at a location as long as there is a sustainable loosestrife population. The dispersal of *Galerucella* spp. beetles within a site was imminently noticeable in 2002. Extensive surveys revealed increased numbers of adults, eggs and larvae throughout more of the area at each of the Columbia Lake, Paulinskill and Whittingham sites. The dispersal of the beetles to other heavily infested loosestrife areas of the Hainesville site continues to be hindered by the foraging of whitetail deer. *Galerucella* spp. eggs and larvae are destroyed when foliage is eaten, thus slowing down the population buildup at this site. The Amwell Lake site first showed significant dispersal within a site in 2000 (Scudder et. al. 2000) and it continues to be heavily impacted by the beetles.

Once the population of beetles reaches a level that results in significant reduction of loosestrife, some of the beetles will start to expand their search area for other loosestrife

infestations. In 2002, the first off-site dispersal by the beetles was documented. A nonrelease site 1.85 miles (determined by using GPS readings) from the Amwell Lake site was discovered to have *Galerucella* spp. adults and egg clusters infesting the purple loosestrife at the site. Field personnel discovered a second site during a pre-visit to a scheduled new release site in Morris County. All life stages of the *Galerucella* spp. beetles were observed at the site, as well as significant feeding damage to loosestrife plants. Records showed that the closest release site to this new area was four miles (determined by using GPS readings) away at The Great Swamp National Wildlife Refuge. The Wildlife Refuge has been making *Galerucella* spp. releases since the mid-1990s. These two new sites now inhabited by *Galerucella* spp. beetles show an important phase has been reached in our establishment and control program. Both the Amwell Lake and Great Swamp sites have experienced significant increases in beetles and corresponding reductions in loosestrife populations in the past two years and the beetles are now starting to search out new infestations of purple loosestrife.

Even though the establishment of *Galerucella* spp. beetles in NJ has been very successful since the initial releases in 1997, the PABIL has continued its release program in an attempt to hasten the dispersal of this important predator in NJ, as well as provide beetles for commercial sale to other states and agencies. Improved rearing techniques by the PABIL have resulted in high numbers of beetles available for release in each of the past six years (Table 2). If this had not occurred there would not have been a sufficient supply of beetles available to meet the demands of this popular and successful program. A total of 1,300,375 beetles has been released into 65 sites since 1997.

Table 2. Number of *Galerucella* spp. Beetles Released, 1997 – 2002

Year	No. Released	No. Release Sites
1997	50,030	5 (5)[1]
1998	222,283	8 (3)
1999	228,363	20 (19)
2000	353,251	20 (13)
2001	242,875	14 (13)
2002	203,573	20 (12)
Totals	**1,300,375**	**65**

[1]Numbers in parenthesis are the number of new release sites for the year.

Galerucella spp. Impact

One of the more frequent questions asked when discussing the use of *Galerucella* spp. beetles to reduce a purple loosestrife stand is, "How long will it take to reduce the loosestrife population?" There is no set answer to that question because a number of factors, such as the size of the infestation, the number of beetles released, the success of the beetle's establishment at the site, and environmental conditions within the site all have a bearing on the length of time needed to effect a control of this invasive weed. Suffice it to say, it is a long-term project, with the literature suggesting that a minimum of 3-5 years is needed before significant control becomes evident (Internet 1999). The first measurable control results that were seen in our program was at Amwell Lake in 2000.

Amwell Lake received its first releases in 1997. In 2002, Columbia Lake and Whittingham joined Amwell Lake, which continued to show good control. By examining the test data that has been collected over the past six years, we can measure the effectiveness of the *Galerucella* spp. impact on the purple loosestrife. One such item that can be looked at is the number of loosestrife stems in the test quadrats at each site (Table 3). The 2001 data is included for comparison.

Table 3. Comparison of the Average Number of the Purple Loosestrife Stems Over A Six-Year Period.

Site	Fall 1997	Fall 2001	Fall 2002
Amwell Lake	38.2	40.4	19.4
Columbia Lake	36.4	47.0	24.0
Paulinskill	30.4	35.4	36.4
Whittingham	25.8	41.2	25.8

The reduction at Amwell Lake continues to be noteworthy both numerically as well as visually (Figure 3 and Figure 4). This site, which is smaller than most of the other sites was heavily infested with purple loosestrife. It received the first releases made by the PABIL and the number of beetles released was higher than the number released at some of the larger sites. This was done in order to bring about faster control results, which it did.

1997 2001

Figure 3. Amwell Lake Loosestrife Population in 1997 and 2001

The changes observed at Columbia Lake, especially in the population of beetles, were very similar to those observed at Amwell Lake in 2000. The visual reduction of loosestrife was not as noticeable however, because Columbia Lake is so much larger. Whittingham's size also precludes a dramatic visual change in its loosestrife population as compared to Amwell Lake even though the site did have a noticeable reduction in the test quadrats. The results at Paulinskill are not indicative of what is occurring at the site because the releases were not made as close to the test quadrats as in the other sites. Paulinskill is another large site and the beetles have not made significant inroads to the area where the test quadrats are located. There has been good feeding damage and loosestrife reduction in the immediate areas surrounding the points where the releases were made.

Another example of *Galerucella* spp. effectiveness is the return of native wetland plants such as cattails, *Typha latifolia.* Cattails compete very poorly with loosestrife and can be quickly overwhelmed by the invasion of the loosestrife. Table 4 demonstrates the resurgence of the cattails over a six-year period. The 2001 data is included for comparison.

Table 4. Comparison of the Average Number of the Cattail Stems Over A Six-Year Period.

Site	Fall 1997	Fall 2001	Fall 2002
Amwell Lake	1.6	6.8	7.0
Columbia Lake	0.8	1.8	3.2
Whittingham	3.0	0.2	0.4

Once the loosestrife population is reduced, the cattails, as well as other native wetland plants, will start to make a comeback. The cattail population at Amwell Lake has made a significant resurgence (Figure 4). Columbia Lake is also making a good comeback, but again the size of the site as compared to Amwell Lake makes the process slower and not so dramatic. Whittingham appears to be losing some of its cattail population, at least in the test quadrats, although there has been a slight increase in the past two years. What is probably slowing the return of cattails at Whittingham is a resurgence of native sedge plants. This site has a much higher population of sedge plants than it does cattails compared to the other two sites. Paulinskill does not have a large cattail population. None of the test quadrats have cattails, which is the reason they were not included in the table. Purple loosestrife is a very prolific flower and seed producing plant. A mature loosestrife plant can produce up to 3,000 flowers, which in turn can result in the production of as much as 2.5 million seeds per year. With such a production capability, it is easy to see how this invasive weed can quickly overtake a wetland. Since seed germination is the primary method by which loosestrife spreads, it stands to reason that reducing the ability of the plant to produce seed will curb its rate of spread.

Figure 4. Close up of Amwell Lake in 1999 (top) and 2000 Photo by R.C. Chianese

The feeding of *Galerucella* spp. larvae in significant densities can result in suppression of flower development (Blossey et. al. 1991). By counting the numbers of inflorescences of the five tallest plants, the total number of inflorescences per quadrat per site and the number of flower buds in a five-centimeter

section of the inflorescences, a measurement of the effects of *Galerucella* spp. larval feeding on the flower and seed production of purple loosestrife can be shown**.** Tables 5-7 show the results of *Galerucella* spp. activity on the plants within each quadrat after a six-year period. The numbers shown in the table are the average for each site.

Table 5. Comparison of the number of inflorescences of the five tallest Purple Loosestrife plants over a six-year period.

Site	Fall 1997	Fall 2002
Amwell Lake	24.04	6.68
Columbia Lake	14.68	11.52
Paulinskill	12.08	10.28
Whittingham	6.0	3.64

Table 6. Comparison of the total number of inflorescences of Purple Loosestrife plants per quadrat over a six-year period.

Site	Fall 1997	Fall 2002
Amwell Lake	173.8	56
Columbia Lake	272.4	123.8
Paulinskill	171.8	146.4
Whittingham	62.4	35.6

Table 7. Comparison of the number of flower buds in a 5-cm section of the inflorescence over a six-year period.

Site	Fall 1997	Fall 2002
Amwell Lake	42.7	34.1
Columbia Lake	45.0	36.1
Paulinskill	47.4	37.9
Whittingham	49.6	18.9

The feeding of first instar larvae on the apical meristem, reduces plant growth and can limit or prevent a plant from producing flowers. All four-test sites have experienced a decrease in flower production since 1997. The large increase in the number of beetles observed at Columbia Lake and Whittingham in 2002 resulted in the corresponding reduction in the flower production at these sites. This is the same effect that was noticed at Amwell Lake in 2000 when the number of beetles dramatically increased at that site. A decrease in the production of flower buds also occurred at all four of the sites, with Whittingham experiencing the most significant reduction. The combined effects of adult and larval feeding on the stems and inflorescences of loosestrife can effectively reduce the population of purple loosestrife. This in turn will allow the native plants to once again become competitive and eventually reclaim their prominence in the wetland.
Table 8 shows the average % coverage for purple loosestrife at the initial release sites. The mean average of the category rating for each of the five quadrats at each site was used to arrive at the average % coverage for each site. The % coverage rating gives an indication of the amount of the quadrat that the purple loosestrife covers as opposed to other plants. The higher the coverage category rating is, the greater the proportion of

purple loosestrife there is within the quadrat. The rating is an indication of how well the purple loosestrife is competing with the other vegetation.

Table 8. Average % Coverage of Purple Loosestrife at the Initial Release Sites*

Site	Fall 1997	Fall 2002
Amwell Lake	82.5	36.0
Columbia Lake	72.5	43.0
Paulinskill	62.5	87.5
Whittingham	43.0	43.0

% Cover Categories Ratings

Category	A	B	C	D	E
0-5	0-5	5-25	25-50	50-75	75-100
Midpoint	2.5	15	37.5	62.5	87.5

*The Average % Coverage Categories have been adapted from the Purple Loosestrife Monitoring Protocol, Second Draft developed by Dr. Bernd Blossey of Cornell University in 1997 but have been converted to the USDA-APHIS protocols so that numbers could be used instead of letters. This change allowed both sets of data to be evaluated the same way.

The percent coverage of purple loosestrife, as compared to the other plant species, is declining at Amwell Lake and Columbia Lake. Both sites have had significant increases in beetle populations with corresponding reductions in loosestrife population. Although Whittingham's coverage of loosestrife appears not to have changed since 1997, this does not mean that the beetles are not having an impact at the site. This apparent "stabilization" indicates that the loosestrife is not increasing, which by itself is a positive impact. Other test data taken at this site as well as visual observations show that the loosestrife population at Whittingham has decreased since the introduction of the *Galerucella* spp. beetles. The increase at Paulinskill can be attributed to the same distance of the beetle releases from the test quadrats as mentioned previously in other data tables.

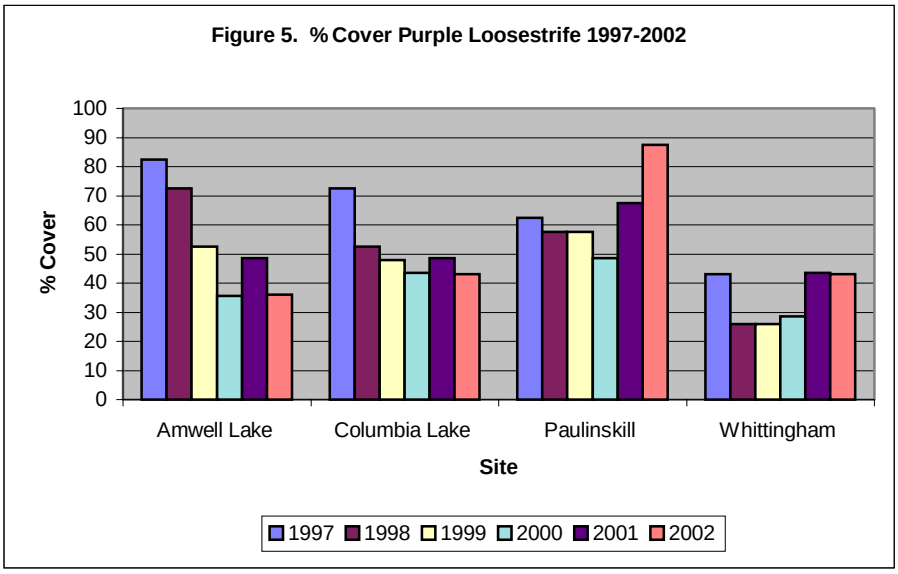

Figure 5 graphically shows the ratings for year to year. The overall trend for the amount of coverage is down. There is variability in the data but even with that the data indicate a decline in the amount of coverage of purple loosestrife in the quadrats and an increase in other plant species. This increases the amount of diversity in the wetland leading to a more balanced ecosystem.

It is well documented that the invasion of purple loosestrife into a wetland can have a negative impact on the native plant species which in turn can cause an endangerment to some of the native wildlife species that depend on the native wetland plants for food and shelter. One such endangered animal species struggling with the invasion of purple loosestrife into its habitat is the bog turtle, *C. muhlenbergii*. The program has been placing *Galerucella* spp. beetles into selected bog turtle habitat sites since 1998. Test data from the bog turtle study sites was inconclusive for all sites but BT V in 2002 (Table 9). At BT V the % cover, # stems, % stems flowering, and the height of the loosestrife plants are all down while the % cover of other plant species has increased. This is all very encouraging and indicates that the purple loosestrife population and its impact should decline in the coming years.

Table 9. Transect Data From Bog Turtle Sites

Site/Year	% Cover of Purple Loosestrife 1-5 by Category	# Stems	% Stems Flowering 1-5 by Category	% Feeding Damage 1-5 by Category	% Cover Other Plant Species 1-5 by Category	Purple loosestrife height	Biocontrol Insects Observed
BT IV 1998	15.8	19.2	3.75	27.5	76.5	136.15	0
BT IV 2002	25.3	15.7	2.5	12.0	67.75	85.2	0
BT V 1998	18.6	25.09	9.09	45.23	73.86	107.73	0
BT V 2002	9.3	10.64	2.5	15.0	87.5	80.01	2 Larvae
BT 4 1999	28.9	10.09	13.64	4.77	75.23	131.27	0
BT 4 2002	35.2	15.27	2.5	14.55	62.95	107.64	0

*Category ratings are below:

% Cover Categories Ratings					
Category	1	2	3	4	5
0-5	0-5	5-25	25-50	50-75	75-100
Midpoint	2.5	15	37.5	62.5	87.5

Previous experience with the original 1997 test sites has shown that fluctuations either positive or negative are not uncommon during the five years it may take the beetles to increase their numbers to the point where their effects start to show any conclusive results. It is anticipated that in time, results, similar to those that are now starting to occur in the original 1997 test sites, will be seen at these sites as well.

CONCLUSION

The success of the PABIL to provide large numbers of *Galerucella* spp. beetles for release and the ability of the beetles to establish and flourish in NJ is starting to have an impact on the purple loosestrife infestation levels within the state. This year for the first time, the sites at Columbia Lake and Whittingham experienced encouraging changes in both the numbers of beetles and loosestrife population. Columbia Lake had a significant increase in beetle population similar to that seen at Amwell Lake in 2000. It had a corresponding positive affect on the loosestrife population although not as dramatic as was seen at Amwell Lake due to its much larger size. The Whittingham site also had a reduced loosestrife population as well as an impressive dispersal of the beetles throughout the entire site. Both the Amwell Lake and the BT V sites continued to show excellent control affects by the beetles again in 2002. The evidence of beetle dispersal to other loosestrife infestations was perhaps the most significant impact seen this year. Population buildup by the beetles has now reached the level at some of the sites that their spread to other areas is naturally occurring. Certainly within the next 5-10 years as the population of the beetles continue to increase and their dispersal into other infested areas naturally expands, increased reduction levels of purple loosestrife infestations can be expected throughout the state.

Production of *Galerucella* spp. beetles will continue at the Phillip Alampi Beneficial Insect Laboratory in 2002 to support all the on-going release programs. The PABIL will continue its cooperative effort with the NJDEP, Division of Fish and Wildlife, Endangered and Nongame Species Program in pursuit of controlling the level of infestation of purple loosestrife in the habitats of the endangered bog turtle. The PABIL will also continue to make beetles available for commercial sale to all who wish to incorporate this method of purple loosestrife control into areas under their management.

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